A Pliocene flora from the Coast Ranges of California

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(WITH PLATE 15)

GENERAL REMARKS

The origin and development of the California floras, particularly the peculiar xerophytic chaparral, has been a problem of no small interest to students of phytogeography. The occurrence in the Coast Ranges of a recognizable Pliocene flora, the only thing of its kind known in North America consisting entirely of living species, partly mesophytic and partly xerophytic in character, throws an interesting light upon the antiquity of these floras and suggests a possible explanation of the isolation of boreal and arctic plants on the upper slopes of high mountains of the state far south of their normal ranges.

THE SANTA CLARA FORMATION

WORK OF PREVIOUS WRITERS

The Santa Clara formation was named and described by Cooper[1] in 1894. The deposit was considered to be of lacustrine origin and referred to the Pliocene on the basis of its general lack of consolidation, the gentle tilting of the beds, and the large percentage of recent species in the molluscan fauna. It had been previously described in some detail by Lawson,[2] however, who also regarded it as Pliocene in age, but of delta origin. The portion lying in the Santa Cruz Quadrangle has been discussed by Arnold[3] and again by Branner, Newsom, and Arnold,[4] its distribution being shown in map form. Recently Jones,[5] solely on lithological grounds, has tentatively suggested its contemporaneity with what has been termed by Lawson and Palache[6] as the Orindan forma-

[1] Proc. Calif. Acad. Sci. 4: 171. 1894.
[2] Bull. Dept. Geol. Univ. Calif. 1: 151. 1893.
[3] Proc. U. S. Nat. Mus. 34: 355. 1908.
[4] Santa Cruz Folio, U. S. Geol. Surv. 6. 1909.
[5] Bull. Dept. Geol. Univ. Calif. 6: 71. 1911.
[6] Bull. Dept. Geol. Univ. Calif. 2: 371. 1902.

tion, and earlier by Cooper[7] as the Contra Costa, a fresh-water deposit of late Miocene age in the Berkeley Hills. The faunal evidence does not bear out such a correlation.

CHARACTER AND DISTRIBUTION OF BEDS

The formation consists of a well-bedded series of clays, slits, and sands with minor gravel strata, of wide extent, underlying and outcropping about the edges of the Livermore, Santa Clara, and San Benito valleys. A large mass fills a formerly extensive depression southwest of Mt. Hamilton, of which San Felipe Valley is a part. Remnants extend south as far as Cook P. O. in San Benito County, a distance of nearly a hundred miles from Livermore. The occurrence of sediments about Portola, thirty miles west of the latter point, indicates a considerable breadth at this latitude. The northward extension of the former lake is uncertain, since the sinking of the San Francisco Bay region in comparatively recent times has permitted the burial of its sediments beneath the valley alluvium.

The thickness of the series is not inconsiderable, but varies widely. In the foothills near Tres Pinos fully 1,000 feet of nearly horizontal strata overlie the Miocene, while the top of the series is cut off by erosion. A section down Calabazas Cañon in the Santa Cruz Mountains, without exposing the basal beds, was estimated to be 3,000 feet in thickness to a point where the upper strata are similarly absent.

It is highly probable that the entire Santa Clara formation was deposited at or comparatively near sea level. The character of the flora furnishes proof that the elevation could hardly have been greater than 1,000 feet and was probably much less. It is difficult to conceive that a single body of water, or quite as probably several connected bodies, of this extent could exist at any considerable elevation in proximity to the ocean continuously for a sufficient period of time to deposit over half a mile of sediments without draining the lake by stream corrosion alone. The enormous thickness of the beds is perhaps explainable on the assumption that the valleys acted as catchment basins with the bottoms sagging beneath the load of sediments. It might be added that

[7] Proc. Calif. Acad. Sci. 4: 169. 1894.

there is a general tilting of the strata toward the middle of each of the three valleys.

The source of the waters which supplied this vast lake, and the outlet to the ocean are uncertain. The large proportion of coarse material in the southern portion of the San Benito Valley suggests that a stream of no small size entered here. It is by no means improbable that the vast expanse of water was kept up by the run-off of the Great Valley of California, through the precursors of the Sacramento and San Joaquin rivers. The lake doubtless fluctuated widely and a considerable proportion of the sediments about the border may have been deposited under fluvial conditions.

FAUNA

Aside from the plant remains, the formation contains a fauna consisting almost entirely of aquatic mollusca,[8] of which a large percentage, six out of ten species, still exist in the waters of northern California.

In the following list the species marked with an asterisk are living.[9]

* *Anodonta cygnea impura* Say
Gonidea angulata Cooperi Arnold
Sphaerium sp. nov
* *Corneocyclas compressa* Prime
* *Planorbis trivolvis* Say
* *Physa* "*heterostropha* Say"
"*Carinifex*" *Sanctae-clarae* Hannibal
* *Paludestrina longinqua* Gld.
"*Amnicola*" *Yatesiana* Cooper
* *Valvata* "*virens* Tryon"

[8] Mr. John Hain, of Cook, California, obtained a leg bone of an extinct Proboscidian from these beds near Tres Pinos. So far as the writer is aware no other recognizable mammal remains have been found in the formation.

[9] Names in quotation marks are subject to revision in a forthcoming paper on the fauna of the Santa Clara formation. *Amnicola Yatesiana*, which in reality belongs to the allied genus *Phyrgulopsis*, is confined to these beds. The genus appears to be valuable for horizon determination in the later Tertiary fresh-water deposits of California.

GEOLOGIC RELATIONS

The youngest formation antedating the Santa Clara is the Purisima, a marine deposit, older Pliocene in age. The Purisima is confined chiefly to the ocean front, but an embayment extended from Half Moon Bay and Pescadero across the Santa Cruz Mountains past La Honda and Portola to the hills near Stanford University and the mouth of Stevens Cañon, while another arm extended inland from Santa Cruz to the vicinity of Chittenden.

The relation of the Santa Clara to the underlying Purisima formation, along the flanks of the Santa Cruz Mountains is probably one of decided unconformity, though the incoherence of the beds has prevented its actual observation. The tilting of the Purisima, which is apparently somewhat greater than that of the Santa Clara, and the differences in distribution of the two indicate that important structural movements took place in the interval previous to the opening of the Santa Clara period.

The older Pliocene through the Coast Ranges appears to have been a period of peneplanation. The movements which preceded the Santa Clara epoch developed the general outlines of the present topographic features. The relief of the mountain ranges was, however, far more gentle than at present, and the elevations of the mountains themselves decidedly less.

Since the deposition of the Santa Clara, several important geologic events have taken place in the history of the Coast Ranges.[10] Following the Santa Clara sedimentation, apparently without the intervention of any other deposits, the entire Coast Ranges were lifted more or less bodily, carrying the old lake level to an elevation of perhaps 4,500 feet above the sea. Rapid erosion ensued and the soft lacustrine beds were cut into deeply, far below the present valley floors. This period of intense elevation and erosion called the Sierran epoch, was widespread in California. It is regarded as marking the opening of the Quaternary, corresponding at least in part to the Glacial epoch of elevated or more northern regions. Subsequently a period of depression ensued, succeeded by temporary oscillations, which have continued to the present. The beds of the Santa Clara formation in the San Benito Valley

[10] Lawson, A. C. Bull. Dept. Geol. Univ. Calif. **1**: 115, 242. 1893. Smith, J. P. Science II. **30**: 346. 1909.

and about Evergreen and Los Gatos in the Santa Clara Valley now reach an elevation of 1,200 to 1,500 feet.[11]

The unconformable deposition of the valley alluvium upon the Santa Clara has taken place more or less continuously since the close of the Sierran epoch. At Madrone, as an alluvial fan of the Coyote River, it reaches the maximum elevation of 345 feet.[12] At least a portion of the alluvium must be referred to the Quaternary from the presence of mammal remains characteristic of that age in gravels near Mountain View.[13] Hence it must not be assumed that the Sierran epoch, though a very long period, was coincident with the entire Quaternary.

The latest event, and a purely local one, has been the sinking of the San Francisco Bay region, causing a flooding of the Golden Gate River system by the tides. As a result the Santa Clara sediments reach an elevation of not more than 500 feet at Mission San Jose, north of that point they largely disappear beneath the later alluvium.

AGE OF THE FORMATION

The Santa Clara formation may be regarded as having been deposited during late Pliocene time. It occupies an unconformable position upon the Purisima, a marine formation of older Pliocene age. It contains a molluscan fauna of which two-thirds of the species are still living. The strata were intensely elevated and eroded subsequent to their deposition, during the Sierran epoch, early Quaternary.

The Santa Clara is presumed to be contemporaneous with the Deadman Islands formation of San Pedro Harbor, Santa Monica Cañon, and Packard's Hill, Santa Barbara, a marine deposit occupying an analogous stratigraphic position in southern California.

LOCALITIES WHERE PLANTS WERE OBTAINED

Plant remains are abundant almost everywhere in the Santa Clara formation, but recognizable material has been obtained

[11] In the vicinity of Bird Creek, near Hollister, the beds, in a disturbed condition, reach an elevation of 1800 or 1900 feet. This is probably produced by local conditions, due to the proximity of the San Andreas fault, along which the earthquake of 1906 took place.

[12] Branner, J. C. Jour. Geol. **15**: 3. 1907.

[13] Santa Cruz Folio, U. S. Geol. Surv. **1909**: 6.

from only five localities, and by far the larger part was derived from two. No doubt careful search would have revealed many more and would materially extend the flora, but the incoherent character of the beds restricts collecting to fresh exposures, to be found only in cañons and gorges. Furthermore, collecting is possible only during the summer and fall months after the matrix has dried out sufficiently to stand transportation to the laboratory.

The localities are as follows:

PORTOLA: gulch below Holliday's ranch in creek-cut about 1,000 feet above mouth of gulch, ⅓ mile south of Portola, Santa Cruz Mountains. The mollusk beds just below this point have been known for a number of years to the Stanford University Geological Survey. Plant beds were found by the writer in 1908. Subsequently collections were made in 1909 and 1910, and in connection with Dr. J. P. Smith and party of students in 1910.

STEVENS CAÑON: creek-cut just above "big camp ground," a flat planted with *Eucalyptus* trees, about 1½ miles above mouth of gorge, Stevens Cañon, Santa Cruz Mountains. Found by W. G. Hannibal, the writer's father, in 1909. Subsequently visited in connection with Dr. Smith and party of students, 1910. The material consists almost solely of *Salix* and lignitized wood.

CALABAZAS CAÑON: "reef" in creek bed at nose of bend above second wagon bridge, ¼ mile from mouth of gorge, Calabazas Cañon, Santa Cruz Mountains. Found by the witer in 1908, subsequent collections made in 1909 and 1910, in connection with Dr. Smith and party of students in 1910, and with Mr. H. M. Edson of Palo Alto in 1910.

SOLLY RANCH: near a spring tunnel on Solly Ranch north of Bird Creek, ¾ mile west of old dairy on mesa above San Benito River, and 4 miles southwest of Hollister, Gavilan Range. This locality was discovered a number of years ago by the owners of the ranch when digging for water. A specimen is contained in the collection of the late Miss Annie R. Laws, now the property of the Geological Museum at Stanford University. The locality was visited by the writer in 1908 and again in 1910 with Mr. Edson. All the best material was derived from the tunnel.

BEAR VALLEY: forks of a small gulch below limestone hill, over ridge 2 miles northeast of Cook P. O., Bear Valley, Gavilan

Range. Mr. John Hain, an old resident of Bear Valley, interested in natural history, pointed out this locality to Dr. C. H. Gilbert a number of years ago. It was subsequently visited by Dr. Smith, Mr. Fordyce Grinnell, Jr., and the writer in 1907, and by the writer in 1910. The main exposure apparently represented an old tule bed, consisting of an interlacing mass of indeterminate carbonized stems in peaty clay. Farther up the same branch of the gully a few fairly well preserved leaves were obtained.

LIST OF PLANTS OBTAINED FROM THE SANTA CLARA FORMATION

	Portola	Stevens Cañon	Calabazas Cañon	Solly Ranch	Bear Valley
Alnus rhombifolia Nutt.	A		X	A	
Amelanchier alnifolia Nutt.			X		
Arbutus Menziesii Pursh	R				
Arctostaphylos Manzanita Parry	R		R		
Cephalanthus occidentalis L.	R		X		
Cercocarpus betulaefolius Nutt.			R		
Cornus glabrata Benth.			A		R
Grossularia Menziesii (Pursh) Cov. & Britt. (?)	R		X		
Padus demissa (Nutt.) Roem.	R		X		R
Pasania densiflora (Hook. & Arn.) Oerst.	A		X		R
Populus trichocarpa Torr. & Gray	A				
Pseudotsuga taxifolia (Poir.) Britt. (?)			R		
Psoralea physodes Dougl.			X		
Quercus agrifolia Née			R		
Quercus chrysolepis Lieb.	X		A		
Rhamnus californica Esch.			R		
Rhamnus Purshiana DC.	X				
Salix fluviatilis Nutt. (?)			A		
Salix laevigata Bebb	A	A	A	R	
Sequoia sempervirens (Lamb.) Endl.	X				

A abundant, X not common, R rare.

NOTES ON SPECIES[14]

PINACEAE

Pseudotsuga taxifolia (Poir.) Britton. Douglas spruce.

A single badly water-worn cone unlike that of any other western conifer is referred with doubt to this species.

A common conifer in the yellow pine belt, particularly the upper portion, and fog belt. British Columbia and South Dakota south to Monterey County, California, northern Mexico, and western Texas.

[14] Determinations have been made in each instance by comparison with recent material in the Stanford University Herbarium.

Sequoia sempervirens (Lamb.) Endlicher. (PLATE 15, FIG. 3.) Redwood.

The characteristic species of the fog or redwood belt of the Coast Ranges. California-Oregon boundary to Monterey County, California.

SALICACEAE

Salix laevigata Bebb. Bebb willow.

Occurs along streams, its zonal distribution being determined by stored water rather than by rainfall. Siskiyou County, California, to northern Lower California.

Salix fluviatilis Nuttall. Long-leaf willow.

The resemblance of the leaf parts of *S. exigua*, *S. argophylla*, and *S. fluviatilis* renders it impossible to decide which of the three the series at hand should be referred to. It is not generally agreed that the several members of the *fluviatilis* group represent more than a single polymorphic species.

Sand bars along valley streams. British Columbia, Mackenzie Basin, and southeastern Canada south to Lower California, northern Mexico, and the District of Columbia.

Populus trichocarpa Torrey and Gray. Black cottonwood.

Several of the specimens show the characteristic anastomosing venation and cordate bases of leaves from young shoots.

Along foothill streams in moist situations, usually with *Acer californicum* and *Fraxinus oregona* in central and northern California. Occurs from southern Alaska east to Montana and south to San Diego County, California.

BETULACEAE

Alnus rhombifolia Nuttall. (PLATE 15, FIG. 6.) White alder.

Occurs along foothill and low mountain streams. Eastern Washington and Idaho south to San Diego County, California.

FAGACEAE

Pasania densiflora (Hook. & Arn.) Oerst. (PLATE 15, FIG. 8.) Tanbark oak.

The venation of this species is unmistakable.

Characteristic of the yellow pine and fog belt, but extending

a short distance beyond Sequoia into the chaparral belt. Southwestern Oregon to Santa Barbara and Mariposa counties, California.

Quercus chrysolepis Liebmann. (PLATE 15, FIG. 2, 9.) Cañon oak.

Several acorn cups and a large series of leaves, nearly all of the small smooth form from mature trees, are at hand.

A characteristic member of the more humid portions of the chaparral belt. Southwestern Oregon to northern Lower California.

Quercus agrifolia Née. Live oak.

A species of wide zonal distribution, occurring in the redwood, yellow pine, foothill, and chaparral belts. Mendocino County, California, to northern Lower California.

GROSSULARIACEAE

Grossularia Menziesii (Pursh) Coville & Britton. Cañon gooseberry.

A number of specimens agree fairly well with this species. The identification is a doubtful one, however, since the leaves of the members of this genus are not readily distinguishable.

Stream banks, southern Oregon, south nearly to San Francisco Bay in the Coast Ranges.

ROSACEAE

Cercocarpus betulaefolius Nuttall. Birch-leaf mahogany.

A typical chaparral shrub. California-Oregon boundary south to northern Lower California.

MALACEAE

Amelanchier alnifolia Nuttall. Western serviceberry.

A single specimen having the strong frequent venation and smooth margin of the form called *A. pallida.*

Chaparral belt. Alaska east to Lake Superior, south to California-Mexico boundary and New Mexico.

AMYGDALACEAE

Padus demissa (Nuttall) Roemer. Western chokecherry.

The impressions show little of the serrated margins character-

istic of this species. This is due doubtless to state of preservation, since it is more or less true of the other serrate species as well.

Best developed in the more humid portions of the chaparral belt, but extends into more arid portions on the one hand and into the redwood and yellow pine belts on the other. Northern British Columbia east to the Rockies and south to northern Lower California.

FABACEAE

Psoralea physodes Douglas. Chaparral psoralea.

Several imperfect specimens of the broad-leaved form were secured.

Characteristic of the more humid portions of the chaparral belt. Humboldt to Los Angeles counties, California.

RHAMNACEAE

Rhamnus Purshiana De Candolle. (PLATE 15, FIG. 10.) Cascara sagrada.

The material at hand shows no tendency to intergrade with the following species though the latter is regarded by some as a subspecies of *R. Purshiana*.

Cañons and river bottoms of the fog belt. Puget Sound region and Idaho south to Mendocino County, California.

Rhamnus californica Eschscholtz. (PLATE 15, FIG. 7.) California coffeeberry.

Occurs chiefly in the intermediate zone between the fog belt and chaparral belt, frequently on open hillsides, but extending into the chaparral with *Arbutus*. Humboldt County, California, to northern Lower California.

CORNACEAE

Cornus glabrata Bentham. (PLATE 15, FIG. 4.) Bentham's dogwood.

Most of the Calabazas Cañon material shows a pair of strong lateral veins near the base of the leaf. The character is more pronounced than in most of the herbarium material examined. The specimen figured retains traces of the original leaf structure.

Foothill streams in rather moist situations. Humboldt County south to Monterey County, California.

ERICACEAE

Arbutus Menziesii Pursh. (PLATE 15, FIG. 1.) Madrono.

The character of the venation in the only specimen obtained is decidedly more infrequent than usual in this species. It is possible that additional material will necessitate its specific separation.

Best developed with the redwood, but extends into the chaparral, yellow pine, and foothill belts. Southern British Columbia to southern California.

Arctostaphylos Manzanita Parry. (PLATE 15, FIG. 5.) Common manzanita.

Two specimens from different localities belong to *A. Manzanita* or one of the nominal species grouping with it. Discrimination cannot be made on the leaf parts alone.

A typical chaparral plant. Overlaps with *Sequoia* along the edge of the fog belt. Ranges from near the Oregon-California line east into the northern Sierra Nevadas and south to Mt. Tamalpais, California.

RUBIACEAE

Cephalanthus occidentalis Linnaeus. Button bush.

Several leaves, all of which show more numerous secondary veins than usual in this species.

Occurs along borders of lowland streams and ponds. Oregon and southeastern Canada to Mexico and Florida.

CONCLUSIONS

COMPARISON WITH OTHER FLORAS

The obvious feature in a comparison of this with other fossil floras is its very recent character. So far as the material might be identified every species is living in the Coast Ranges today. It is distinctly unlike the older Tertiary floras of the west, since their contents, palms, laurels, broad-leaved oaks, etc., are types indicating moist, nearly tropical conditions. The floras of the middle and upper Miocene are as yet largely undescribed.[15] From

[15] Lesquereux, L., Proc. U. S. Nat. Mus. **11**: 35. 1889, has reported *Diospyros virginiana* L. var. *Turneri* Lesq., *Magnolia californica* Lesq., *Laurus* cf. *canariensis* Heer, *Viburnum* cf. *rugosus* Pers., and *Vitis* sp., and F. H. Knowlton in Turner, H. W., Jour. Geol. **6**: 498. 1898, notes *Populus* sp., *Alnus* sp., *Castanea* sp., *Vaccinium* sp., and *Arbutus* sp. from Kirker's Pass near Mt. Diablo in the San Pablo

these some recent species may be expected and a comparison can then be made. However, the important changes in climate and humidity, which took place in the continental history of California at the opening of the Pliocene[16] have gone a long way toward eliminating these types. With their extinction appeared full-fledged and apparently unheralded, the modern California flora. It is obvious that the several peculiar genera and numerous species which characterize it could not have come into existence and become fixed types in the brief interval, geologically speaking, between the upper Miocene and late Pliocene. It is reasonable to assume that this flora, already developed to its present high specialization, immigrated from elsewhere, where, through a very considerable period of time, it had evolved.

The Santa Clara flora cannot be compared with other floras of corresponding age, since no other Pliocene floras have been described from North America.[17] Such floras occur in England[18] and other parts of Europe, but consist entirely of local species. Quaternary plants are known in the Loess of Canada[19] and the marine deposits of Maryland[20] but are likewise too remote to afford comparison.

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formation, Upper Miocene, associated with *Astropadsis Whitneyi* and other characteristic marine mollusca. No magnolias or chestnuts are now indigenous to California, and but few of the other species have any living relations west of the Rocky Mountains.

[16] While the stratigraphic relations of the Contra Costa and Kettleman Lake beds are known with considerable certainty, of the entire faunas, totaling some twenty species of fresh-water mollusks, only two, *Anodonta cygnea impura* and *Paludestrina longinqua*, are common to the two formations. These occur again in the Santa Clara beds and still exist, widespread, from southern Oregon east to the Rocky Mountains and south well into Mexico. The other Contra Costa species suggest strongly the fauna living in the lower Mississippi Valley. The Kettleman fauna on the other hand is the precursor of the existing central California fauna.

It seems probable that the abrupt change of conditions which eliminated the Miocene flora was coincident with that which eliminated the Miocene fresh-water mollusca. The latter took place during the comparatively brief interval separating the Contra Costa and Kettleman periods of sedimentation, and it is presumed the former did also.

[17] Knowlton, F. H., Jour. Geol. **18**: 116. 1910, has reported *Woodwardia* sp., *Sassafras* sp., and *Sterculia* sp. from the Falls of the Columbia River, in beds said to be of Pliocene age.

[18] Reid, C., & E. M. Jour. Linn. Soc. **38**: 206. 1908.

[19] Dawson and Penhallow. Bull. Geol. Soc. Am. **1**: 311. 1890.

[20] Hollick, A. Pliocene and Pleistocene. Md. Geol. Sur. **1906**: 148, 217.

All the species live today in the Coast Ranges of California north of San Francisco Bay. Indeed one familiar with the plants of that region would immediately identify this flora with that which inhabits the valleys of Sonoma, Mendocino, and Humboldt counties a few miles from the ocean in the zone of overlap of the redwood belt (Transitional zone) and chaparral belt (Upper Sonoran zone). That it does not show the extreme humid conditions of the open coast is evident from the presence of such species as *Alnus rhombifolia*, and species of *Cercocarpus* and *Arctostaphylos*. On the other hand *Sequoia* delineates it as at least partially fog belt in aspect.

EVIDENCE OF A COLD EPOCH

This flora agrees very well with the evidence of the aquatic mollusca and points to perceptibly colder conditions in central California during Pliocene time, but makes it certain that this cold facies was due not to elevation, but to actual migration of isotherms. Such a condition could not have been a local phenomenon but was probably widespread on the Pacific Coast.

This offers an explanation of the isolated occurrence of numerous arctic and boreal plants on the tops of high mountains far south of their normal distribution. The Santa Clara period was succeeded by the Sierran epoch, when the entire coast seems to have been carried by a great orogenic uplift many hundreds of feet above its present elevation. Very little is known of the climatic conditions which existed in California at that time. The rapid erosion prevented the formation of extensive lakes, and later depressions have carried all the marine deposits of the period even deeper beneath the ocean. This page, torn from the otherwise complete geologic record of the late Cenozoic of the coast, probably corresponds at least partially to the Glacial epoch elsewhere. Hence it is commonly assumed to have been colder and more humid than the present. It seems probable that the northern plants continued to exist south of their present southern limits during the early Quaternary, as a result of the cold epoch, the high elevation, the effects of which would be similar, or both, and were finally isolated toward the close of the Sierran epoch in the middle Quaternary.

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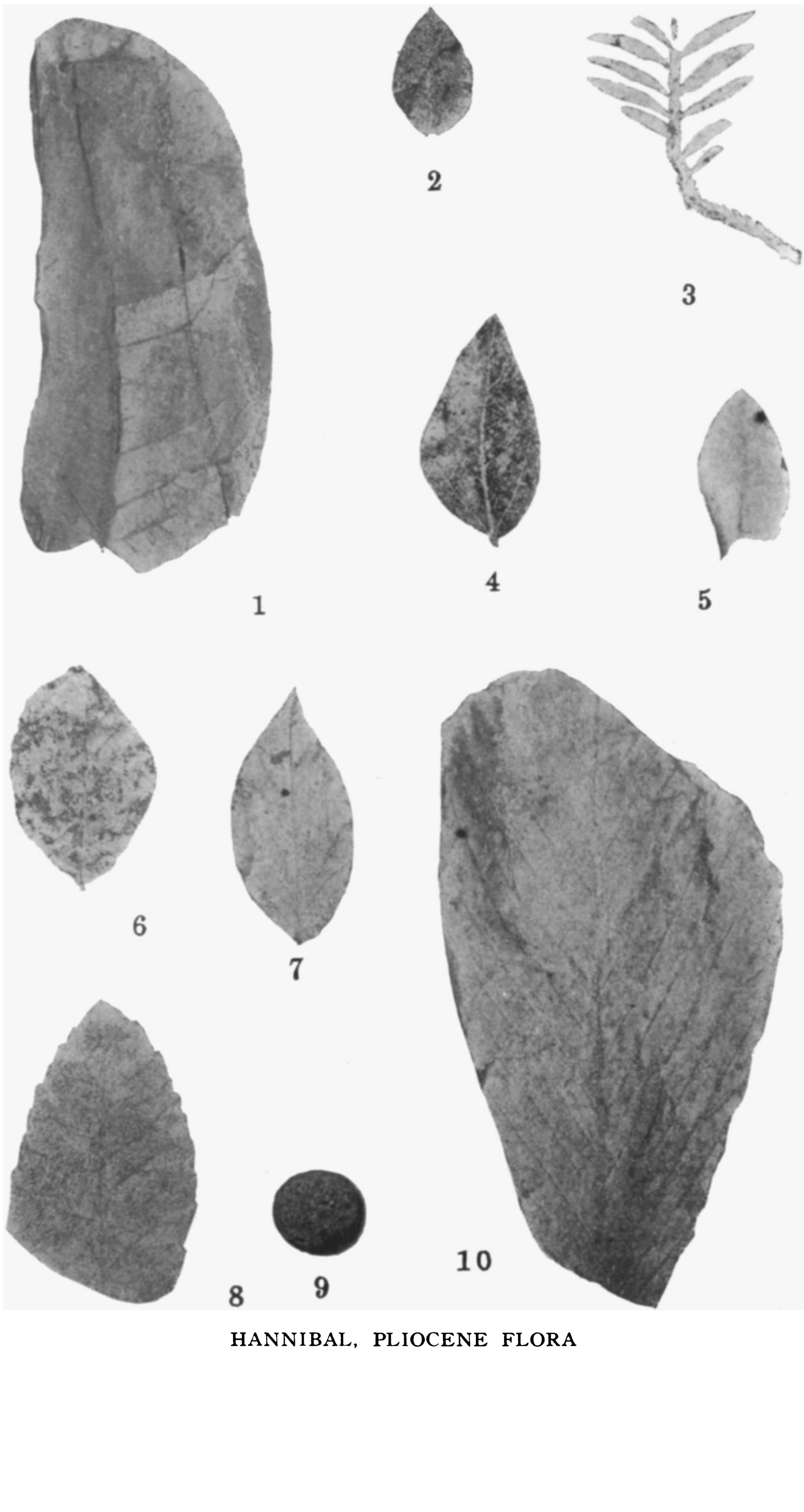
CALIFORNIA.

Explanation of plate 15

(All figures are approximately natural size.)

FIG. 1. *Arbutus Menziesii* Pursh, Portola.
2. *Quercus chrysolepis* Lieb., Calabazas Cañon.
3. *Sequoia sempervirens* (Lamb.) Endl., Portola.
4. *Cornus glabrata* Benth., Calabazas Cañon.
5. *Arctostaphylos Manzanita* Parry, Calabazas Cañon.
6. *Alnus rhombifolia* Nutt., Solly Ranch.
7. *Rhamnus californica* Esch., Calabazas Cañon.
8. *Pasania densiflora* (Hook. & Arn.) Oerst., Portola.
9. *Quercus chrysolepis* Lieb. (inside cast of acorn cup), Portola.
10. *Rhamnus Purshiana* DC., Portola.



HANNIBAL, PLIOCENE FLORA